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Age determination of the Atlantic walrus, *Odobenus rosmarus rosmarus* (Linnaeus), by means of mandibular growth layers

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Receipt of Ms. 6. 7. 1981

Abstract

Examined the growth layers in 112 walrus mandibles (*Odobenus rosmarus* Linnaeus) to determine their applicability in age determination. Growth layers are formed in the lateral portion of the ramus mandibularis in both males and females, from the first year of life until at least the 27th year. The number of mandibular growth layers was found to correspond with the number of annual growth layers in the cementum of the cheek teeth in the ratio of 1 : 1. It is concluded that readings of both mandibular and cheek teeth growth layers should be made when determining the age in the walrus.

Introduction

Dental growth layers are widely used in age determination of seals (e. g. Scheffer 1950; Laws 1952, 1953, 1962; Klevezal and Kleinenberg 1967; Jonsgård, 1969; Morris 1972).

Mohr (1952) called attention to the possibility of using the layering in the tooth cementum in age determination of the walrus (*Odobenus rosmarus* L.). Subsequently, age determination of the walrus has largely been based upon interpretation of cementum growth layers (Brooks 1954; Fay 1955, 1982; Mansfield 1958; Burns 1965; Krylov 1965; Born and Kristensen 1980). Although it is generally accepted that this method is usable, age determination in some individuals is often impeded by indistinctness of cementum growth layers. This is particularly marked in subadult walruses of both sexes and in females of all ages (Fay 1955; Mansfield 1958; Born and Kristensen 1980). Furthermore, attrition of the cheek teeth may impede age determination in older walruses (Burns 1965; Born and Kristensen 1980).

Chapskii (1952) observed growth layers in the mandible of the walrus *(Odobenus rosmarus)* and the harp seal *(Pagophilus groenlandicus)*. He demonstrated that in the harp seal the number of mandibular growth layers is correlated with estimates of age based on other criteria and suggested that the mandibular growth layers are formed annually. However, Chapskii (1952) neither gave a detailed description of the layering in the walrus mandible, nor did he use the layering in age determination of the walrus. Therefore we

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Z. Säugetierkunde 47 (1982) 55–62

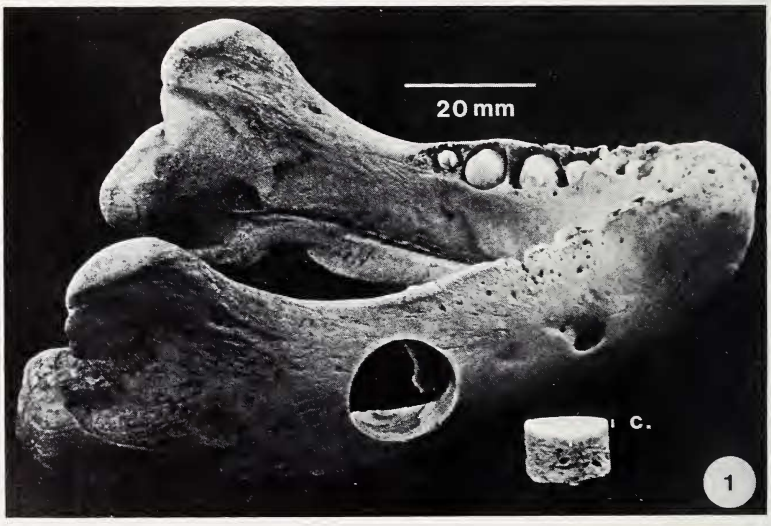
ISSN 0044-3468 / InterCode: ZSAEA 7

decided to study the mandibular layering in the walrus and compare it with the growth layers in the cementum of the cheek teeth in order to determine the aplicability of the mandibular growth layers in routine age determination.

Materials and methods

Mandibles of 88 (47 males and 41 females) Atlantic walruses (*Odobenus rosmarus rosmarus* Linnaeus) from the Thule district, North Greenland, were collected in 1977 and 1978 in connection with an investigation of the exploitation of the walrus in Thule (Born and Kristensen 1980). Of 79 walruses with information on date of kill 50 animals were taken in October 1977 and 29 in the period March–June 1978 in the Thule district. Furthermore, four mandibles (two males and two females) were collected near Disko Island, Central West Greenland, in the period February–March 1978. The mandibles with some soft parts attached were kept frozen until cleaned in the laboratory in September 1978. General cleaning procedure was maceration in water (40 °C) until the soft parts could be removed by lightly rubbing under running tap water. After drying, a five to ten mm thick transverse section was cut on a rotating diamond saw used for preparation of rock samples through the region of the last cheek tooth. The surface of the section were polished with fine-grained sandpaper and studied in a dissection microscope in reflected light at a magnification of 10 ×.

In order to determine the formation of the initial growth layers two foetuses and 20 immature walruses (24 days to about four years old) from the collection of the Zoological Museum of Copenhagen were included in the analysis. Four of the immature animals were Pacific walruses (*Odobenus rosmarus divergens* Illiger) from Wrangell Island (U.S.S.R.) and sixteen were Atlantic walruses (*Odobenus rosmarus rosmarus* L.) from Greenland. To avoid too much damage to the Museum specimens a drilling core, 12 mm in diameter, was taken from the lateral wall of the right ramus mandibularis below the last cheek tooth, instead of a transverse section (Fig. 1). For determination of age by means of growth layers in the tooth cementum the method described by Born and Kristensen (1980) was followed. This method, essentially similar to that of Mansfield (1958), is based on counts of growth layers in root cementum in transverse section of six cheek teeth from each animal. The undecalcified sections are studied under reflected light and the age in years is assessed as the mean number of growth layers in all sections.

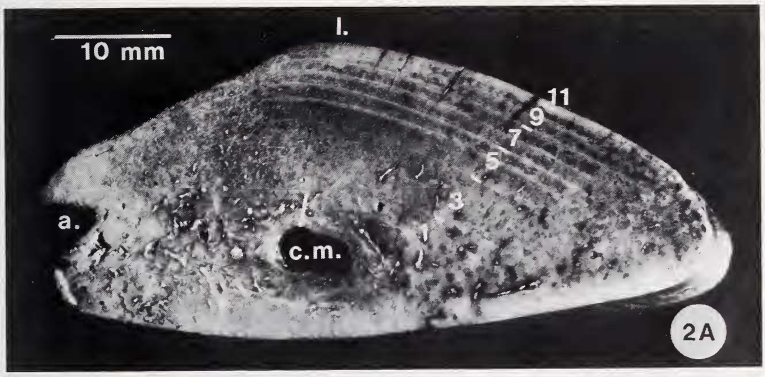


Results

The combination of a broad zone of bone tissue succeeded laterally by a narrow, primary incremental line will constitute a "growth layer" in the description of mandibular growth. A corresponding annual growth layer in the tooth cementum comprises a broad opaque zone followed by a narrow translucent band.

In the mandibles of two foetuses (age: about two months and 24 days prepartum, respectively) only spongy bone tissue had been formed. In seven neonates (age: from 24 days until about four months postpartum) a 1–2 mm thick zone of homogeneous compact bone tissue had been formed on the lateral surface of the ramus, while the lingual portion of the mandible consisted of spongy tissue (Fig. 1). In three one-year-old calves (age: 10 to 14 months) one fully-formed growth layer was found in the mandible as well as in the tooth cementum. One of these calves lived in captivity in the Copenhagen Zoo from October 1975 until 24 July 1976 and was reported to be 14 months old by death.

When two to three growth layers have been formed the mandible consists almost exclusively of compact bone tissue.



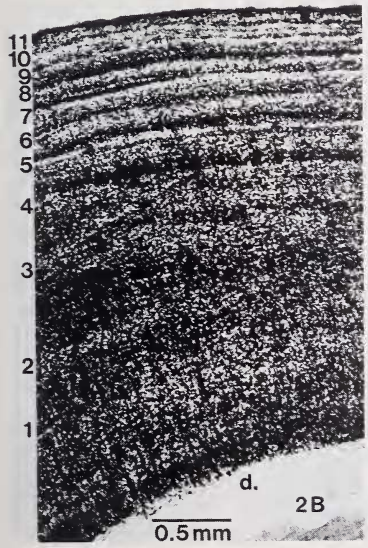


Fig. 2. Transverse sections of the mandible and the tooth cementum of a male walrus with eleven growth layers (Thule; October 1977)

A: Transverse section of the right ramus mandibularis (Reflected light). 1: Laterally; a: Alveole of the last premolar; c. m.: Canalis mandibularis. – The bar indicates where the first growth layer was measured. (Photo: G. Brovad. Z. M.)

B: Transverse section of the cementum of the lower p. m. 2. (Transmitted light). d: Dentine. – Note that the initial growth layers in the mandible and the tooth cementum are more indistinct than the following layers. (Photo: G. Brovad. Z. M.)

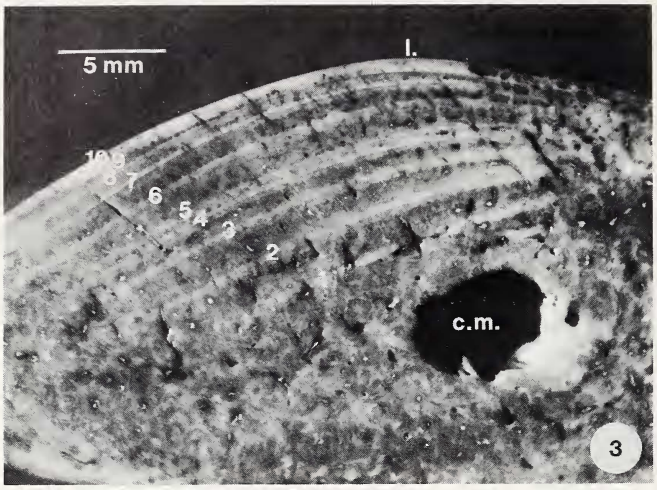


Fig. 3. Transverse section of the right ramus mandibularis of a female with ten growth layers (Thule; May 1978); (Reflected light). 1: Laterally; c. m.: Canalis mandibularis. – Some of the primary incremental lines appear as double lines. (Photo: G. Brovad. Z. M.)

In 20 subadults and five adults series of transverse section with five to ten mm intervals were cut along the whole length of the right ramus mandibularis. Growth layers were seen in all sections but were most distinct in the region of the last cheek tooth. New growth layers are formed on the lateral surface of the ramus in both males and females and are often particularly distinct in the portion lateral to the canalis mandibularis (Figs. 2A, 3, 4).

It can thus be concluded that the first growth layer is formed after birth during the first year of life, in the mandible as well as in the tooth cementum.

A neonatal line in the mandible of the sperm whale (*Physeter catodon* L.) was described by Nishiwaki et al. (1961). No such line or zone separating the prenatal and the postnatal portion of the mandible was found in the walrus. Hence, the first-formed growth layer in

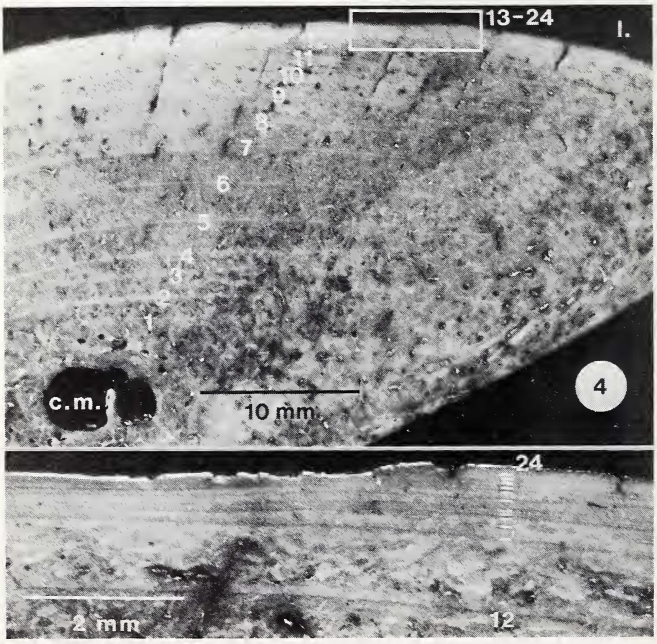


Fig. 4. Transverse section of the right ramus mandibularis of a male walrus with about 24 growth layers (Disko Island, May 1978); (Reflected light). 1: Laterally; c. m.: Canalis mandibularis. – The first incremental line is partially resorbed. (Photo: G. Brovad. Z. M.)

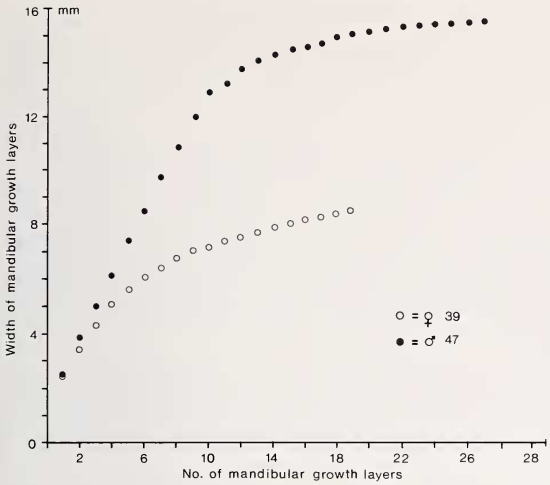


Fig. 5. Accumulated average widths of mandibular growth layers in the walrus (*Odobenus rosmarus rosmarus* L.) from the Thule district, North Greenland. Note that the width of the first growth layer includes bone formed prenatally (see text for explanation)

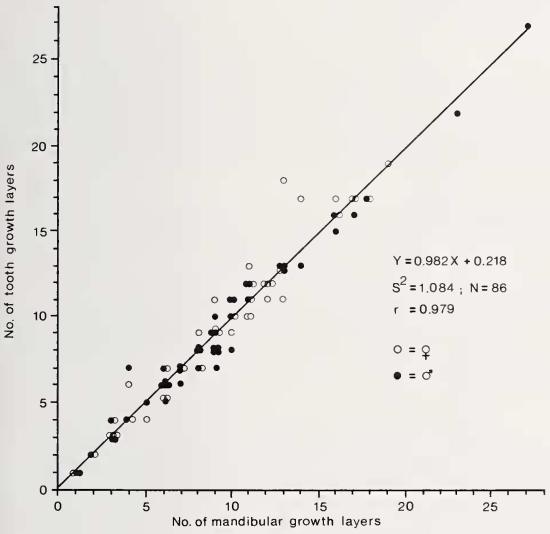


Fig. 6. The relationship between the numbers of growth layers in the tooth cementum and the mandible of the walrus (*Odobenus rosmarus rosmarus* L.) from the Thule district, North Greenland

the walrus mandible was measured from the lateral edge of the canalis mandibularis to the lateral edge of the first incremental line and includes the prenatal tissue (Fig. 2A).

In many specimens the initial two to four mandibular growth layers are more indistinct than the following layers. This we attribute to the accelerated growth in the premature life of the walrus as reported by Fay (1955, 1982), Mansfield (1958), Krylov (1965) and Born and Kristensen (1980). When about six to ten growth layers have been formed in the male mandible, and about four to eight layers in the female, there is a decrease in the average thickness of the mandibular growth layers (Fig. 5). A similar deceleration in the growth rate is also observed in the layering of the tooth cementum (Mansfield 1958; Born and Kristensen 1980) and, presumably, reflects a decrease in overall body growth at attainment of sexual maturity.

The relationship between the numbers of mandibular growth layers and growth layers in the tooth cementum is shown in Figs. 2 and 6. The slope of the regression line (Fig. 6)

does not differ from 1.0 ($t = 0.824$, $P > 0.10$, d. f. = 84) and the intercept of the line does not differ from 0.0 (95 % conf. int. for $\bar{Y}$ corresponding to $X = 0.0$: -1.82 to 2.26). Thus, there is a syncrony in the formation of growth layers in the mandible and in the tooth cementum. The number of growth layers in the two tissues corresponds on a ratio of 1 : 1. Differences in the numbers of growth layers found in the two tissues reflect the uncertainty in interpretation of growth layers, rather than real differences in rate of formation. The 95 % confidence intervals of the regression line (Fig. 6) are ± 2.04. In the few individuals where the difference between the number of mandibular and tooth cementum growth layers exceeds the 95 % confidence interval more layers were counted in the tooth cementum. These animals are an immature male and female (four mandibular layers) and two mature females (14 and 15 mandibular layers, respectively), Fig. 6. Indistinctness of the first-formed growth layers and counting of secondary lines in the tooth cementum explain these variations.

The nature of the peripheral layer in the mandible and in the tooth cementum is shown in the Table. In the majority of individuals from all months there is a zone of bone tissue at the periphery and there is a tendency that this zone becomes broader in the period March–October. In the tooth cementum a translucent zone was found at the periphery in most animals in the period March–July, while 60 % of the specimens had a broad opaque zone at the periphery in October. Our presumption, that the formation of the narrow incremental line in the mandible is synchronous with the formation of a narrow translucent zone in the tooth cementum is not readily supported by the Table. However, in both tissues the nature of the narrow peripheral layers are difficult to perceive and we suppose, that in many cases the peripheral incremental line may have been removed from the mandible during preparation. In the minke whale (*Balaenoptera acutorostrata* Lacépède) parts of the newly-formed bone tissue are removed from the periosteum in bulla tympanicum during preparation (Christensen 1980).

Resorption of the initial growth layers occurs at a variable age, but in none of our specimens had resorption progressed so far that the initial layers were not partially represented among the Haversian canals (Figs. 3 and 4).

The oldest of our specimens (15 October 1977) had 27 growth layers in both mandible and tooth cementum. However, at only one site along the lateral surface of the mandibular transverse section were the 16 outermost growth layers present. These 16 growth layers

Table

The season of formation of the layering in the mandible and the tooth cementum in the walrus (*Odobenus rosmarus rosmarus* [L.]) from the Thule district, North Greenland

	Mar.	Apr.	May	Jun.	Jul.	–	Oct.
Mandibles							
Nature of bone under formation							
Narrow incremental line	0 %	20 %	20 %	20 %	–	– –	10 %
Narrow zone of bone tissue	86 %	60 %	60 %	30 %	–	– –	28 %
Broad zone of bone tissue	14 %	20 %	20 %	50 %			62 %
No. of animals	7	5	5	10			50
Tooth cementum							
Nature of zone under formation							
Narrow translucent zone	86 %	33 %	95 %	100 %	96 %	– –	40 %
Broad opaque zone	14 %	67 %	5 %	0 %	4 %	– –	60 %
No. of animals	7	3	20	8	34	– –	43

totalled 1.5 mm in thickness. Mansfield (1958) found walruses up to 28 years of age in Hudson Bay and Burns (1965) reported a 33-year-old walrus in an Alaskan sample. The finding of mandibular growth layers in a 27-year-old walrus indicates that age determination from mandibular layering offers a useful tool in age determination even of very old walruses.

Secondary lines were seen in the mandible of some animals. In the broad zone of bone tissue in the one-year-old calves an indistinct secondary line was observed. A similar line was present in the opaque zone of the initial growth layer in the tooth cementum of some animals. The reason for this secondary line is obscure, but the long period of suckling in the walrus (approximately two years; Mansfield 1958; Fay 1982) may influence on the regularity of the initial growth layers. In older walruses secondary lines may be present in the broad zone of the mandibular growth layer. The secondary lines appear irregularly in the normal growth layer sequence and are generally less distinct than the true primary incremental lines. Thus, we consider the chance of confusing secondary lines with primary incremental lines in age determination as low. Primary incremental lines may appear as closely-situated double or triple lines that fuse ventrally and dorsally (Fig. 3).

Conclusions

In the walrus one mandibular growth layer corresponds to one annual growth layer in the cementum of the cheek teeth.

Mandibular growth layers are easier to distinguish than tooth cementum growth layers. Because mandibular layers are thicker, more sharply defined, and not influenced by eliminating processes they are more suitable in age determination than tooth cementum growth layers.

The preparation of transverse sections of walrus mandibles is a quick and simple process.

We therefore recommend that the counting of mandibular growth layers should be included with counting of growth layers in the tooth cementum in routine age determination of the walrus.

Acknowledgements

This study was supported by funds from the Danish Natural Science Research Council and the Commission for Scientific Research in Greenland.

We wish to thank Dr. T. Kristensen, Zoological Museum of Copenhagen, who collected and prepared some of the material. We also wish to thank Professor K. G. Wingstrand and Dr. H. Grue, Institute of Comparative Anatomy, Copenhagen, and Dr. E. Platts, Department of Zoology, Queens University, Belfast, for reviewing the draft and offering useful critism.

Zusammenfassung

Altersbestimmung beim Atlantischen Walroß, Odobenus rosmarus rosmarus (Linnaeus) durch Zuwachslinien der Kiefern

Die Zuwachslinien wurden in 112 Walroßkiefern, *Odobenus rosmarus rosmarus* (Linnaeus) studiert, um über ihre Verwendbarkeit zur Altersbestimmung zu entscheiden. Im lateralen Teil des Ramus mandibularis werden bei beiden Geschlechtern Zuwachslinien vom 1. bis wenigstens zum 27. Lebensjahr gebildet. Die Zahl der Zuwachslinien im Kiefer stimmt mit der Zahl der Zuwachslinien im Zement der Backenzähne überein, im Verhältnis 1 : 1. Eine Zuwachslinie wird jährlich gebildet. Zählung von Zuwachslinien im Kiefer sollten daher zusätzlich zur Zählung von Zuwachslinien des Backenzahnzementes für die Altersbestimmung des Walrosses durchgeführt werden.

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BUCHBESPRECHUNGEN

Stephenson, W. K.: **Grundlagen der Zellbiologie.** Struktur – Moleküle – Stoffwechsel. Ein Lernprogramm. Übers. u. bearb. von L. Hafner. Berlin und Hamburg: Paul Parey, 1980. 235 S., mehr als 200 Abb., Karte zum Abdecken der Musterantworten, Bal., DM 30,–. ISBN 3-489-60634-5.

Das vorliegende Buch wendet sich an Teilnehmer von Einführungskursen der Zellbiologie für Botaniker, Zoologen und Mediziner und ist zum Selbststudium geeignet. Es unterscheidet sich von ähnlichen Werken durch die didaktische Konzeption, denn es vereinigt gleichzeitig knapp und prägnant gefaßte Einleitungstexte zu den einzelnen Kapiteln nach Art eines Lehrbuches mit einem gut durchdachten Lernprogramm mit Fragen und Musterantworten. Jeweils nach einigen Kapiteln ist für die einzelnen Lerneinheiten ein Lösungsschema eingeschaltet, an das sich Tests zur Selbstüberprüfung anschließen.

Das Buch berücksichtigt die Strukturlehre, die biochemischen und physikalisch-chemischen Grundlagen und die Grundlagen des Zellstoffwechsels. Es dürfte als Unterrichtshilfe von großem Wert sein. D. Starck, Frankfurt/M.